Stathem (I. H.)

ON THE RELATIONS

OF

METEOROLOGY TO YELLOW FEVER.

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I.

The Climatic Conditions of 1853, as Stated by Dr. Edward H. Barton.

The question of the origin, or producing cause, of yellow fever has probably engaged more attention than any other of the zymotic diseases; and probably no line of physical inquiry so perseveringly and persistently followed, has yielded less in results of a positive character.

In an examination into the relations of cause and effect, where the former is unknown, but suspected, it is rational to search for a similarity in the suspected phenomena, whenever like effects are manifested.

Our physical welfare is so intimately associated with all that pertains to the atmosphere, that in seeking for any facts or circumstances that may throw any light upon the question of causation of special forms of disease, such as yellow fever—a disease known to exist only within a certain climatal zone—we observe with interest any atmospheric changes, or departures from the normal condition, which may present any evidence favoring a solution of the unknown problem. In this direction there has probably been no more eminent and indefatigible observer than

Presented by the author.

Dr. E. H. Barton, of Louisiana, whose labors cover a period of more than a quarter of a century, previous to and during the terrible visitation of yellow fever which scourged the inhabitants of the Southern states in 1853.

Dr. Barton himself maintained a meteorological record of great value and completeness, he having first introduced the hygrometer into the system of meteorological observation in Louisiana. But it was not alone in the observation and record of the indications of the several instruments employed that his great work was accomplished. In the successful application of meteorological values to the study of their relations to physiological and pathological investigation, the student of such relations should himself be the observer and compiler of meteorological data, and should be not merely competent to observe and record the indications of the different instruments, but should be also an *observer* in its widest sense—one, who from natural qualifications and training, is accustomed to reason within himself upon the complex and ever varying phenomena constantly presented to his observation.

Dr. Barton possessed these qualifications in an eminent degree, peculiarly fitting him for the task of preparing for the Sanitary Commission of 1854, the climatal and pathological history of the epidemic of 1853. He formulated a theory of causation for yellow fever, or more especially of epidemics, based upon a combination of meteorological and *terrene* conditions which he likened unto a pair of "shears"—neither of whose blades could be operative without the other. In the history of the epidemic of 1853, he pointed out in an admirable manner the existence of these combined conditions in New Orleans during that year.

As the question of sanitation does not belong to the purposes of this paper, I will only state briefly that these *terrene* conditions consisted in very great and primary disturbances of the soil created by digging out a basin, or "head," for the Carondelet Canal. This necessitated the excavation of the soil over an area many thousand yards square, and to a depth of perhaps twenty-five feet. Also in cleansing out and throwing upon its banks, to dry in the sun, the bottom of the original canal; in dredging the bank canal, deepening the ditches upon certain streets, in the most central part of the city; throwing up earth in the construction of a

levee on the lake shore, four miles in the rear of the city; excavations upon miles of streets for the purpose of laying gas and water mains, and for paving; excavations for new buildings, for railroad purposes, etc. Furthermore, at this period there were no fixed regulations for the maintainance of a proper sanitary care of the city. These constituted his "terrene" conditions, which only required a certain combination of meteorological elements to ripen into an epidemic of deadly consequence.

While the meteorological conditions of 1853 were unseasonable, even as early as the month of January—both temperature and humidity being above the normal, which condition continued during the months of February, March and April, it was during the month of May. that these special and remarkable departures from the normal condition were manifested in so prominent a manner that Dr. Barton was enabled, as early as the middle of that month, to predict the terrible visitation which followed.

Following the record into June, we find an augmenting of the special characteristics of a high temperature with high dewpoint, the maximum temperature being several times above 90°; an exceptionally high barometer, and from the 9th of the month thereafter, rain showers of almost daily occurrence. "A stagnant atmosphere and the presence of vegetable mould." "A very great and unusual radiation," says Dr. Barton, "evinced an elemental derangement." During the month of July, the maximum temperature was but 89 degrees, and the average slightly under 80 degrees (a very low temperature for the month of July in New Orleans). The average humidity was 82.5 per cent.—lacking but 17.5 per cent. of saturation.

The average at sunrise was 93 per cent. The barometric pressure, as during the month of June, continued high, being 30.265.

During the month of August the meteorological features of this combination reached their maximum intensity—the maximum thermometer being 91°—average 81.5°—barometric pressure 30.194—less than during the previous month, but still above the

[The average humidity for the month of July in New Orleans, according to a twelve years' showing by the U. S. Signal service, is 72.9 per cent.]

[The normal pressure is about 29.99.]

normal, with a relative humidity of 87.3 per cent., lacking but 12.7 per cent. of complete saturation, and but 5 per cent. less than saturation at sunrise. Solar radiation reached the maximum for the year on the 19th day of the month, being 148°. The rains during the month were of almost daily occurrence, and *tropical in character.*

Here, then, we have during the month of August the higher values of all those climatal elements which are considered to be favorable to the fomentation of yellow fever poison; and during this month, also, we find the greatest mortality from yellow fever —5,269 deaths; the highest daily mortality occurring two days after the occurrence of the highest solar radiation for the year.

In the month of September there was a decided fall of temperature—the average being 76.2 degrees. This was fully five degrees less than for August, although the *relative humidity continued high*, being 85.7. The number of deaths during this month was 1,066 —hardly more than one-fifth the mortality of the previous month.

Such is a brief resumé of the meteorological conditions accompanying the epidemic of 1853, *evidenced by the instruments employed.*

Appended to Dr. Barton's meteorological table for the months of July, August and September, 1853, are the following notes of his observations during these months:

JULY.

"Much thunder and lightning during the month. Heavy rains alternated with hot sun. Much damp weather.

AUGUST.

"Much thunder and lightning during the month; during the intervals of the heavy rains, a burning sun: cold in shade; hot, damp and suffocating air; more 'calms' than ever before observed; the average force of the wind very small. * * * The gutters, when stagnant water left twelve hours after a rain, had gas bubbling up from below—turbid, discolored."

SEPTEMBER.

"The occurrence of thunder and lightning continued as long as the rains. The north winds and cool, dry weather occurred soon

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[The greatest mortality from yellow fever generally occurs in September.]

after the middle of the month, greatly abating the epidemic."

These brief notes, which but few observers would have considered worth observing or recording, speak volumes in describing the special conditions of the atmosphere attending the epidemic. Many characteristics are recorded as being peculiar to this year, which are absent or present only to a limited extent, during years of normal healthfulness.

From the records of the Sanitary Commission some facts are obtained which are pertinent to this subject: "An agriculturalist in this city noticed that his seeds failed to germinate, or when they did so, they would sprout up a few inches and then wilt and die from sudden blight. He applied to his neighbors engaged in the same business to replenish his stock, but found they had suffered from the same blighting influence. Many fowls, old and young, died without having appeared to be primarily sick. These influences were not confined to New Orleans, but existed wherever the epidemic prevaded as such. On the coast of Texas fish were found dead in immense numbers.

"At Biloxi, the peaches rotted on the trees; great mortality existed among the fowls; flies and musquitoes remarkably numerous; mould on the trees.

"At Bay St. Louis there was an epidemic among fowls.

"At Bayou Sara, the China trees had a sickly appearance, and their leaves were covered with crustaceous *larvæ*.

"At Centreville, the musquitoes were more numerous than ever before observed; mould very abundant and of a drab color; season unusually wet and heat of sun very great.

"At Lake Providence, fowls were very sickly—many having bumps upon them; musquitoes ten-fold more numerous than ever before known. A peculiar smell pervaded the atmosphere of the place."

Dr. McAlister stated to the Sanitary Commission that "he had never seen such repeated floods, attended with such an excess of thunder and lightning, succeeded by such hot sultry days during the latter part of summer;" and so on *ad libitum*.

Such were some of the atmospheric influences observed during the summer of this most remarkable year, *of which the meteorological instruments gave no indication.* In ascribing the epidemic to

a combination of "meteorological and terrene" conditions entirely out of the normal state, Dr. Barton certainly made out a strong case.

II.

Has the experience of 1853 been borne out in subsequent epidemics?

Although yellow fever existed to a considerable extent in 1854, 1855, and 1858, the next formidable epidemic occurred in 1867.

It is believed that no meteorological records were kept in New Orleans, during that year, so that its climatal features cannot be studied except in a general way from memory. This is a very unsafe reliance in statistical deduction or in any investigation where absolute accuracy is necessary; but from my personal recollection there was much hot, humid weather during the early part of summer, followed by dry northerly winds during September. I very distinctly recollect the frequent occurrence of hot "steaming" rains, alternated with hot sun. Later in the season, during the prevalence of dry winds, the characteristics of a high radiation—*i. e.* hot sun and cool in shade, were so well marked that the instrumental record is unnecessary to prove its existence, but, of course, without the thermometer, no comparison can be made with other years.

The fever reached the maximun, in intensity, about the first of October, and it was about this time that the usual autumnal storm occurred.

Proceeding to the greater epidemic of 1878, we are abundantly supplied with data by the records of the U. S. Signal Service, established in 1871.

The year 1877 was normally healthful and free from yellow fever.

The year 1878 was characterized by the severest epidemic of yellow fever experienced since 1853. The year 1879 was one of the most healthful years in the history of New Orleans, although there occurred a few sporadic cases of yellow fever. Having here three consecutive years so much at variance in their records of mortality and states of general healthfulness, let us compare their

climatal characteristics with a view to corroborate the theory of Dr. Barton, as applied to his able analysis of the year 1853.

Considering first the barometric pressure, we find upon examination of the records for the months of May, June, July and August, that during each of these months the pressure was lower in 1878 than in either of the healthful years, 1877 and 1879; that the averages for the four months were, for 1877, 30.078; for 1878, 29.965; for 1879, 29.985. Thus in the epidemic year the barometric pressure was lower during the months which may be considered as fever-producing, than during the two healthful years; and furthermore, the higher pressure prevailed during the year which was entirely free from yellow fever.

Here is a direct contradiction to the experience of 1853 in regard to atmospheric pressure, and at first view we should dismiss this factor from further consideration.

Next, considering the question of a combination of a high temperature and high humidity, we find that the averages of temperature for these months were, for 1877, 79.16°; for 1878, 81.22°; and for 1879, 78.72°—an average for 1878 of 2.06° over 1877, and 2 5° over 1879.

The average humidity was for 1877, 66.78 per cent., for 1878, 70.85 per cent., and for 1879, 69. per cent.—an excess for 1878 of 4.1 per cent. over 1877, and of 1.85 per cent. over 1879. Here then we find a strict confirmation of Dr. Barton's theory—the records showing that both temperature and humidity were markedly higher for these four months in 1878, than during either of the corresponding periods of 1877 and 1879. Furthermore, that the year 1877, which was absolutely free from yellow fever, had a lower dew-point, though higher temperature, than 1879, the phenomenally healthful year, but the one wherein occurred a number of sporadic cases of yellow fever.

The total numbers of rainy days during these four months, were for 1877, 37; for 1878, 56; and for 1879, 44;—another confirmation, if we accept the conclusion that an increased number of rainy days, (the *amount* of precipitation not considered) is favorable to the augmentation of yellow fever. I do not assert that Dr. Barton made any distinct claim in this direction, but he did, and with

great propriety, lay particular stress upon the *character* of the rains—such as are alternated with a hot sun.

In this direction I shall point out that during the month of August, 1879, there were seventeen rainy days—more than during the corresponding month of 1878—but from personal and special observation, these were remarkably cold rains for the season of the year in this latitude; and were not accompanied by the hot "steaming" weather that in some years characterizes our summer ~~homes~~. The greater humidity of August, 1879, over that of 1877, was caused by these frequent rains, but it was not a harmful humidity, being associated with a lower temperature.

Referring again to the *terrene* conditions in New Orleans, I am not aware that any extended excavations were made during either of these three years under consideration, or that the state of cleanliness was more marked in one year than another. It is true that early in the spring of 1879 the New Orleans Sanitary Association was organized, and did institute very great improvement in the sanitary condition of the city. But while the healthy condition of the city in 1879 might very properly be attributed, in a measure, to the efforts of this association, no such claim could be made for the year 1877.

Referring to Dr. Barton's record for 1853, we find very frequent reference to the subject of solar and terrestrial radiation, as having a marked influence upon the epidemic of that year. He shows that during the months of July, August and September the line of direct solar heat was remarkably high; and that its rise was coincident with the rise of the fever; that the highest point recorded was 148°, —on August 19th; and in referring to his tables of mortalities we find that the greatest daily mortality occurred three days later; which is certainly more than a coincidence, when we remember that the period of incubation for this disease is generally placed at from three to five days.

Unfortunately this branch of meteorological inquiry has been but little studied here, and we have no records for the years 1877–78–79, which we have been considering. Fortunately the records of the Board of Health from 1872 to 1875 inclusive, under the presidency of the late Dr. C. B. White, contain complete daily records of solar radiation by the black-bulb thermometer. The

thermometer was exposed at an elevation of twenty-five feet. Dr. Barton's instrument being situated fifteen feet above the ground, so that the data can very well be compared.

We find that during the months of July, August and September, 1872, the maximum of radiation exceeded 130 degrees on 82 days of these months, and exceeded 140 degrees on 32 days, the highest being 150 degrees, on August 11th.

In 1873, the degree of radiation exceeded 130 degrees on 61 days, but at no time during the year exceeded 140 degrees.

In 1874, the degree of radiation exceeded 130 degrees on 65 days, but did not at any time exceed 140 degrees.

The averages for the three months were, for 1872, 137.3; for 1873, 130.2; and for 1874, 131.3; being a daily average of 7.1 degrees for 1872 over the year 1873, and of six degrees over 1874.

In 1875, the maximum of radiation exceeded 140 degrees only once, on September 1.

There is such a remarkable departure in the amount of radiation between the years 1872, and the three next following, during the yellow fever period, that we are led to search for some correlation between the meteorological figures and the intensity or other circumstances attending the sporadic fever during these years. An examination of the barometric records for the months of July, August and September does not show any marked departure from the normal pressure. The averages for 1872–73 were a little higher than for 1874. The average temperature was for 1872, 83.26°; for 1873, 81.14; and for 1874, 82.55. The relative humidity was slightly higher in 1873 than in 1872, but was very considerably lower in 1874 than in either of the previous years. The higher average temperature of 1874 was caused by the "heated term," which lasted about twenty days. There was no rain during this hot period, except a light shower, and the dew-point was very low. So there is nothing in these figures to engage attention, except that in 1873, the lines of humidity and temperature were less separated than in either of the other years, and thus more nearly approached "yellow fever weather," considered from the Barton standpoint. We have then only to consider, as having a particular bearing upon the question of yellow fever in this case,

the very great difference in the solar radiation of 1872 over the years 1873–74.

In 1872, there were 83 cases of yellow fever, the first case occurring about September 1. The first seventeen cases could not be traced to any source of importation.

In 1873, there were 388 cases of yellow fever, clearly traced to importation, the first case having resulted fatally on July 8th.

In 1874 there were about twenty cases classed as yellow fever by the Board of Health, but this fever was of very doubtful character, many of the cases being considered as of a malarial type by the attending physicians. Some of the cases contracted the fever at Pascagoula, Miss., and others at Havana, Cuba; notwithstanding which fact, but twenty cases occurred in all.

From a meteorological standpoint alone the sporadic cases of these years are very easily studied superficially, when we note that in 1872, there was a very high radiation and a temperature higher than in 1853, but a lower dew point.

In 1873 there was a low degree of radiation, but a dew point more nearly approaching yellow fever conditions.

In 1874 there was no element favorable to yellow fever growth, except a high temperature. We might, without any very great exercise of the imagination, assign as a sequence of the high radiation of 1872, the apparent indigenous character of the fever of that year.

In 1873 the element of moisture was more favorable to yellow fever, although not in a marked degree, and we find nearly five times as many cases as in the previous year. In 1874, there was no element which we consider essential to yellow fever propagation; and although the fever was imported from two sources, but twenty cases occurred, and some of these complicated with the native malarial fevers.

This latter mentioned fact is in confirmation of a belief of Dr. Barton and others, that yellow fever is only a higher grade of remittent fever, aggravated by an augmentation of the meteorological or other causes, which give rise to the latter. But not desiring to intrude upon the domain of the medical profession, I merely mention the fact, as appearing to furnish a slight confirmation of that theory.

From personal recollection, I am enabled to state that the year 1873 was an exceptional year, meteorologically speaking, in that it was characterized by an early spring, accompanied by a very advanced state of vegetation; but accompanied also by very great and sudden changes of temperature. Even as late as April 10, a white frost was said to have occurred upon the low ground in rear of the city; but this was probably an error. It was in no sense a "yellow fever" year, considered from our usual standards of observation.

Through the courtesy of Mr. Delano, in charge of the U. S. Signal Station at Shreveport, La., and his assistant, Mr. Hill, I am enabled to consider the question of this relation of climate to yellow fever at Shreveport, where an epidemic of very great severity occurred in 1873. This epidemic commenced about the middle of August, and reached its maximum of daily mortality on the 15th of September.

As the atmospheric conditions for the year do not present any marked departure from other years, I shall consider the months of July, August and September only, as affecting the question of yellow fever. I find the barometric pressure so near the usual value, as to be left out of consideration. The average temperature was lower than the ten-year average for July and August, and but slightly higher for September.

The relative humidity was about equal to the ten-year average for July, but three per cent. higher for August, and three and 4-10 per cent. lower in September; so that the only apparent combination is in the nearness of the lines representing the temperature and humidity. This was a special feature of 1853, 1873 and 1878 in New Orleans.

New Orleans, August 12, 1885.

III.

What is requisite to increase our efficiency in the study of yellow fever causation from a meteorological stand-point?

In reviewing the climatic features of the great epidemics of yellow fever, as far as our limited data permit, we find it difficult to make out a case in favor of any distinct theory in regard to yellow fever causation.

We find that in 1853 certain conditions did exist—so ably set forth by Dr. Barton—notably an abnormally high barometric pressure. In 1878, during our epidemic, ranking next to 1853 in point of intensity, we find a barometric pressure below the average; and also below the same factor for the next preceding and succeeding year—the same months only considered.

There is some analogy between the relative humidity of the years 1853 and 1878, but not sufficient to enable us to assign this element as the *vera causa* of the disease. In 1853 the highest daily mortality was 244 on August 21st, and 235 on the 22d. In 1878 the highest daily mortality was about 100,—this latter in a population of about 200,000. This was equivalent to an annual mortality of 182.5 per 1,000 population. The maximum mortality of 1853 was equivalent to a yearly mortality of 385.5 per 1,000 population. The intensity of the epidemic in 1853 is thus shown to have been more than twice that of 1878, judging from the effect on the destruction of life.

In considering alone the elements of temperature and humidity how are we to determine the status of these elements essential to produce a resulting effect in intensity of the disease? It is self-evident that no such deduction can be made. Passing on to a consideration of the temperature alone, the most thoroughly studied of any meteorological element, we find from the records that in nearly every year in New Orleans the average temperature has been above the standard necessary for the existence and spread of yellow fever, and higher than the average for 1853—the yellow fever period being alone considered.

The average temperature, from twelve years' observation by the U. S. Signal Service, is for July, August and September a higher value for each month than obtained for the same months in 1853. The twelve years' average humidity for these months is for July, 72.9 per cent., for August, 73.4 per cent., and for September, 72.4 per cent. In 1853 the monthly averages, as before stated, were for July, 82.5; for August, 87.3; and for September, 85.7. So that since the same conditions obtained in 1878, in a minor degree, we must admit the influence of a certain combination of moisture and temperature in the make-up of the conditions requisite to the fomentation and augmentation of this disease. But if we depend upon this condition alone, we shall find ourselves at fault; because in many years of average healthfulness we have experienced longer or shorter periods of a temperature sufficiently high for yellow fever, and the simultaneous occurrence of a very high dewpoint. Nevertheless, any one who has made a study of the matter has recognized the fact that yellow fever requires a climate of a high degree of moisture.

That cholera, again, requires a distinct climature from yellow fever is evident from the fact that these diseases do not exist simultaneously at the same place: as witness the history of cholera and yellow fever in New Orleans during the years 1832, 1849, 1853 and 1873. In the latter year, the late Dr. White, in his history of the cholera outbreak, called especial attention to the existence of very unusual meteorological conditions in a great and abnormal range of temperature, very sudden and extreme changes, etc. He says, in speakfng of the rain-fall, "April and May, meteorologically, seem to have changed places." The cholera commenced in February, and increased in intensity, attaining its maximum in May; but in June only nine deaths occurred, and none in July—giving place to yellow fever in the latter month, after the meteorological elements had changed.

Dr. Mulvaney, of the British Navy, states that during the prevalence of cholera on board his ship in 1871: "It was not a little remarkable that when the heat reached its maximum, *and brought in its train great humidity and arid stagnation the cholera entirely ceased*; but reappeared as soon as the great heat was over, and the morning and evening atmospheric circulation became again brisk."

I have italicized the above sentence because it is especially pertinent to this subject, of special meteorological conditions governing particular diseases.

But while we recognize an undoubted relation of climate to special diseases, we cannot define any definite relation by the instruments at present employed. We cannot promise that with a certain barometric pressure, degree of temperature or percentage of humidity, a certain disease, or a specific intensity of any disease, will follow as a sequence. It is evident that there is something we have not arrived at; that some facts are missing in our problem.

Much has been written upon the prevalence of certain atmospheric influences, just prior to and during the existence of our greater epidemics, often called the "yellow fever influence," of which our instruments give us no indication. This was especially noted in 1853 and has been referred to on a preceding page; and in 1878, Dr. White, a very close observer and student of atmospheric phenomena, early in the season of that year, stated his conviction that an epidemic of yellow fever would prevail largely in the south-western states.

And not only in this country, but in South America, has this indefinable something, manifest to our senses, been observed and commented upon. In reference to this subject Dr. Barton pertinently says:

"These are more obvious by our feelings than by our instruments, and the day is not distant when these can be stated more precisely."

The purifying effect of thunder storms upon the atmosphere seems to be an unsettled question. In speaking upon this subject Dr. Barton says:

"Storms of thunder and lightning I have noticed for thirty years in this country, to exist during epidemics, and instead of 'purifying the atmosphere,' to injure the sick; they existed throughout the epidemic here and elsewhere last year (1853). They have been noticed during epidemics at Rio and Demarara and other places. It is the opinion of many physicians in tropical climates that this development of electricity increases the number of cases of yellow fever; that in proportion to the violence of the storms, the disease augments in violence, and that it aggravates existing cases."

But should we, finding our present methods insufficient, aban-

don the study of these important relations? Not only should we not relax our vigilance, but we should push our investigations into new fields, continuing our present instruments, as being in no sense unimportant, but as factors in a problem, at some of whose elements we have not yet arrived.

We need a more systematic method of observation and record of special features of climate which have been considered of trivial importance, or as of having no bearing upon the subject under consideration.

The destructive effect of the atmosphere upon animals and plants, mentioned by Dr. Barton in 1853, referred to on a previous page, and observed during severe epidemics, is of itself a matter of importance, as showing that some specific condition existed of which we can have no conception at present.

Happily we have secured through the U. S. Signal Service a thorough and systematic method of observation and record, applied to the whole country, furnishing a uniform system. But there is a very great need of independent observers who have the time, the patience, and love of investigation combined, to conduct special investigation in lines of inquiry not coming within the scope of the work of the U. S. Signal Service.

It is very much to be regretted that no systematic tests for ozone have been made during the presence of yellow fever epidemics. Dr. Barton suggested that it was probable that no ozone existed, or a very small quantity at least, during the epidemic season of 1853; and from my own experience and observation, I should judge this to have been the case in an atmosphere such as he described. As the artificial production of ozone is within our possibilities, the importance of this branch of inquiry is apparent. The Board of Health is now conducting tests in this city and state which will in time furnish data for the study of this powerful atmospheric agent, in relation to yellow fever and other forms of disease.

The element of solar and terrestrial radiation is one that should be studied as presenting anomalies as yet but little understood in this latitude. Since the death of Dr. Barton this subject has not received any attention here, to my knowledge, except during the four years, 1872 to 1875, under the supervision of the Board of Health during that period.

But transcending in importance all other elements, in my judgment, as a meteorological inquiry, no less than in the question under discussion, is the subject of atmospheric electricity. Electrical manifestations in the form of thunder storms, and the general relation of electricity to the animal economy, has been the subject of speculation during a century or more; but owing to the absence of suitable instruments for the observation of this element, as well as a general indisposition to undertake an investigation requiring long and diligent labor before any definite results can be arrived at, this has not yet received much practical attention, within the yellow fever zone especially. Observation has so far been confined to a study of the effects of thunder storms upon the intensity of yellow fever, which is about as effectual as would be the study of barometric pressure by the effect upon the senses of the elasticity of the atmosphere. As affording a reference to the direction of thought upon this subject, and the varied theories advanced by men whose opinions are entitled to our highest consideration, I quote from a distinguished authority—LaRoche.

"If while recollecting the almost universal agency of electricity over the laws of inorganic matter, we take into consideration the diffusion of the fluids in the atmosphere, both in its tranquil and disturbed states; if we bear in mind the close analogy or correlation existing between it and the cause presiding over certain phenomena of innervation; * * * if besides, we consider that the nervous system derives from the atmosphere a portion, at least, of the electrical properties requisite for the performance of its functions, and if, with these facts before us, we recollect that electricity is elicited in the process of the living economy—increased under peculiar circumstances,—and modified by cold, lassitude or sudden motion, we shall discover, in the absence of other and more positive proofs, a strong argument in favor of the conclusion, that from its excess or paucity will result certain modifications, for good or for evil, in the play of the functions.

"We may conclude too, that from the same influences will result various changes in the atmosphere and in the chemical combinations of surrounding objects, calculated to impart to these deleterious properties, or to aid in the diffusion of morbific causes. * * * So evident indeed are the effects mentioned and their connection with electrical states of the atmosphere, that, while unwilling to believe with Foster, that it is not the heat, nor cold, nor dampness, nor draughts of air, which are chiefly concerned in producing disorders, nor the sudden transition from one to another of these conditions, but some *inexplicable peculiarity*

in the electric state, we cannot but admit that in the instances referred to, and others of the same kind, the effects must be sought in the influences assigned, and not, as has been done, in the hygrometric changes which accompany alterations of weather; though these, as well as barometrical and thermometrical variations, contribute to the result."

In reference to this subject I quote also from Doctor Parkes, as showing that later philosophy has not abandoned the question of these relations of electricity to meteorology and physiology:

"That these (electricity and light) as well as heat, are important parts of that complex agency we call climate, seems clear; but little can be said on this point. In hot countries *positive electricity is more abundant;* but the effects of its amount and variation on health, and in the spread and intensity of diseases is quite unknown. All that has been ascribed to it is pure speculation. The only certain fact seems to be that the spread of cholera is not influenced by it."

Doctor Lallemant, of Rio, as far back as 1850, in discussing the question of yellow fever causation, said:

"We cannot deny the greatest analogy, or at least, a most indubitable relation between the electro-galvanic or magnetic action and the process of human life: the first being diminished, the second necessarily becomes deteriorated, and when the reaction from a part of the earth's surface against the atmosphere becomes latent, the process of zootic life ceases. * * * That magnetic needle, the *biometer*, which we may apply to our bodies, to observe the most delicate perturbations—the internal disturbances of our vital forces, inappreciable to our grosser senses—is still wanting to us."

The limited observations so far made upon atmospheric electricity serve as an index to very great annual variations in the quantity, tension, or whatever property of this mysterious agent which affects the instruments employed for its detection—variations which we do not meet with in any other of the atmospheric elements which we have investigated.

Dr. Turley found from four year's observation that by the units of measurement employed by him his results were more than thirteen times greater in December and January than in the months of June and July. I do not know what his methods were or where his investigations were made, but it is presumed that his instrument was of a primitive pattern. Later on we have the record of Prof. Denza at Moncalieri, at the base of the Alps, referred to in the report of the Smithsonian Institution for 1881.

These observations extended over a period of twelve consecutive years, from 1867 to 1878, wherein, employing a different system of units, he shows that the monthly averages do not vary to so great an extent, but finds the potential, expressed in arbitrary units, about fifty per cent. greater in winter than in summer; and what is still more interesting, he found that during some years the potential was about four times greater than during other years; and that this singular anomaly did not present a gradual rise and fall, but occurred sometimes in alternate years;—a year of low, being followed by one of very high potential, or *contra*.

The inquiry presented by this anomalous result in its possible relation to yellow fever alone, is of sufficient importance to merit the most thorough investigation. May we not here find an explanation of the phenomenon of epidemic years alternating with those especially healthful?

These electrical investigations cannot be applied to localities foreign to where they are made, but must be studied in localities where the results are to be applied, as enough is known to satisfy us that very great differences exist in different latitudes and localities in the amount, intensity or other condition of electrical forces. The known law of magnetism—increasing in intensity from the Equator towards the poles—is an indication, worthy of our consideration, that the electricity of the atmosphere is correspondingly augmented in intensity or other condition as we recede from the equator.

It may yet be found that this disease of the tropics—yellow fever, is due, not so much to the temperature of that zone, as to some specific electrical condition of the atmosphere.

In conclusion, it is suggested that the records furnished by the instruments at present employed in the meteorological service are not sufficient to enable us to determine the particular values of the different elements necessary to causation in yellow fever, or at least, that may be assigned as being coincident with that disease.

That, while the present methods of observation are absolutely essential, a more extended investigation is required of those special features of climate which are believed to have a direct relation to this disease as a cause, or at least, to have existence only when that disease prevails.

That, first, the element of radiation is worthy of special investigation in this direction;

Secondly, that atmospheric ozone, and its probable antithisis (antozone), should have thorough investigation;—at least until its relation to sickness and health shall have been demonstrated *pro* or *con*.

Thirdly; the subject of atmospheric electricity, so-called, is believed, to have a paramount relation to the animal and vegetable economy; and may prove to have a more intimate relation to disease, than its most enthusiastic adherents now claim for it.

It is believed that from the efforts of patient and conscientious laborers in the field of investigation, made only in the interest of *truth*, the varied and complex phenomena of nature which make up the aggregate called *climate*, will yield results from which some Kepler of the future will formulate definite meteorological laws.

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